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STATE DOCUMENTS

MONTANA STATE HIGHWAY DEPARTMENT

HIGHWAY PLANNING SURVEY

IN COOPERATION WITH

PUBLIC ROADS ADMINISTRATION

ECONOMIC ANALYSIS AND RECOMMENDATIONS

RELATIVE TO

FEDERAL-AID ROUTE NO. 42

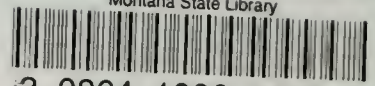
AND

FEDERAL-AID SECONDARY ROUTE NO. 252

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Montana State Highway Department
 Traffic and Planning Section
 Public Roads Administration
 Basic Design Categories
 Table No. 1

: Stan-: Average		: Classifi-: Max.: Max.:		: Sight Distance		: Non Passing		: Passing:		: Shoul-: Width		: Width of		: Minimum		: Minimum	
: dard : Daily		: cation : Grade:Curv-: :		: ature: Curv-: Horiz. : Vertical :		: ature: Curv-: Horiz. : Vertical :		: Feet: Feet		: der : of Road:		: ing		: Type of		: Base	
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0	0-200	20 M	40	7	14	14	14	280	800	3	24	18	Under 1" Oil:	5"			
1	201-400	50 M	40	7	14	14	14	290	800	4	28	20	2" Oil:	6"			
2	401-800	100 M	40	7	14	14	14	310	1100	5	32	22	2 1/2" Oil:	8"			
3	801-1800	200 M	40	7	14	14	14	320	1100	6	34	22	2 1/2" Oil:	8"			
4	1801-3500	300 M	40	7	14	14	14	330	1100	8	38	22	2 1/2" Oil:	8"			
5	0-200	20 M	60	6	6	6	6	460	1700	3	26	20	Under 1" Oil:	5"			
6	201-400	50 M	60	6	6	6	6	460	1700	4	30	22	2" Oil:	6"			
7	401-800	100 M	60	6	6	6	6	470	2100	5	32	22	2 1/2" Oil:	8"			
8	801-1800	200 M	60	6	6	6	6	480	2100	6	34	22	2 1/2" Oil:	8"			
9	1801-3500	300 M	60	6	6	6	6	500	2100	8	38	22	2 1/2" Oil:	8"			

SEE TABLE NO. 2.

Note: Roads having over 3500 vehicles per day require special design.

TABLE NO. 2

Table giving length of vertical curve required for various
Non - passing sight distances

December 18, 1943

Algebraic Difference between grades for convex curvature.	Length of vertical curve for a Non- passing sight distance of: 280 feet	Length of vertical curve for a Non- passing sight distance of: 290 feet	Length of vertical curve for a Non- passing sight distance of: 310 feet	Length of vertical curve for a Non- passing sight distance of: 320 feet	Length of vertical curve for a Non- passing sight distance of: 330 feet	Length of vertical curve for a Non- passing sight distance of: 460 feet	Length of vertical curve for a Non- passing sight distance of: 470 feet	Length of vertical curve for a Non- passing sight distance of: 480 feet	Length of vertical curve for a Non- passing sight distance of: 500 feet
1.00:	96	103	117	125	133	258	269	281	305
2.00:	191	205	234	250	266	516	539	562	610
3.00:	287	308	352	375	398	774	808	843	915
4.00:	382	410	469	500	531	1032	1078	1124	1220
5.00:	478	513	586	624	664	1290	1347	1405	1524
6.00:	574	615	703	749	797	1548	1616	1686	1829
7.00:	669	718	820	874	930	1806	1886	1967	2134
8.00:	765	820	938	999	1062	2064	2155	2248	2439
9.00:	860	923	1055	1124	1195	2322	2425	2529	2744
10.00:	956	1026	1172	1249	1328	2581	2694	2810	3049
11.00:	1052	1128	1289	1374	1461	2839	2963	3091	3354
12.00:	1147	1231	1406	1499	1594	3097	3233	3372	3659
13.00:	1243	1333	1524	1623	1726	3355	3502	3653	3963
14.00:	1339	1436	1641	1748	1859	3613	3771	3934	4268

MONTANA HIGHWAY PLANNING SURVEY

GUIDES FOR ESTIMATING 1960 TRAFFIC

1. 100% = 1941 traffic.

Applies to:

2. 110% = Traffic if route is unim-
to proved at present time but
125% expected to be improved by
1960.

F.A., F.A.S. and Class 1, 2, & 3
Forest Highways. Applies to
sparsely settled rural areas.

(Add extra traffic generated by
logging activities on timber
utilization roads or other major
industries and traffic induced by
these activities).

3. 125% = Traffic if route is unim-
to proved at present time but
150% expected to be improved by
1960.

F.A., F.A.S. and Class 1, 2, & 3
Forest Highways. Applies in
checkerboard well-settled rural
areas or on through-roads.

(Add extra traffic generated by
logging activities on timber
utilization roads or other major
industries and traffic induced by
these activities).

4. 150% = Traffic if route is unim-
to proved at present time but
200% expected to be improved by
1960.

F.A., F.A.S. and Class 1, 2, & 3
Forest Highways. This applies in
exceptional cases such as bottle-
necks and natural cutoffs. Some
cases, of course, might be much
more but these special conditions
would require special analysis.

Note: Date of expected improvement
does not change traffic
estimates for 1960.

(Add extra traffic generated by
logging activities on timber util-
ization roads or other major
industries and traffic induced by
these activities).

130% = expected secular growth 1941 to 1960 -- to be applied to all above
conditions except traffic
generated by logging activities,
or other major industries.

Applies to all roads now constructed.
(Without any of above increases)

Average summer maximum traffic equals double average ADT except on predominately
recreational routes where factor might be as high as 3.

Average summer maximum traffic equals average of several maximum summer days.

Maximum hour equals 10% of maximum summer ADT. (Usual public traffic), or
15 to 20% on roads used by both the public and by major logging operations
or other major industries.

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ECONOMIC ANALYSIS - FEDERAL
AID SECONDARY ROUTE NO. 252
CIRCLE-GLASGOW, 85 MILES

I. ROUTE DESCRIPTION

The route to be analyzed is proposed as a part of the Federal-aid Secondary System. It extends from a point on Federal-aid Route No. 15 in Circle, McCone County, to a point on Federal-aid Route No. 1 in Glasgow, Valley County, by way of Weldon and Fort Peck Dam. From Circle to the Valley County line on Fort Peck Dam the route is unimproved a distance of 71 miles - thenceforth to Glasgow, a distance of 18 miles, the route is improved to presently high standards. The later section was improved as a part of Federal-aid Route No. 42 during the period 1934-1941.

With regard to the future constructed length of the routing, it is reasonable to expect that the distance between Circle and Weldon will be decreased by at least 1 mile and that the distance from Weldon to Fort Peck will be shortened by 3 miles. For purposes of the analysis which follows in this report, see Section IV, the constructed distance from Circle to Fort Peck Dam will be listed at 67 miles.

The route lies in the plains area of Montana touching on the "breaks" of the Missouri near Fort Peck Dam; the topography imposes no special conditions insofar as construction is concerned. The route is unique, however, in that it "bridges" the Missouri River by way of the Fort Peck Dam.

II. TRAFFIC DATA

There are several factors, vocational and recreational, within and outside of the area served by the proposed improvement, which operate to generate traffic. Treating first with the vocational aspects of the case, we find a settled agricultural area from Circle to Weldon - as of 1941, the

records show a relatively high level of "feeder" or secondary traffic, 41 vehicles per day for a distance of 25 miles. Circle is a primary trading center for the farmers of the region, it is a rail-head; the resulting traffic is, therefore, constant, regular, and sustained, and we can be assured that a secondary road tapping the area will do an important service to the local residents. From Weldon to Fort Peck Dam, the route traverses a grazing area with a few scattered farms - the traffic record is correspondingly small, there being but 5 vehicles a mile per day for a distance of 46 miles.

In 1936-1937 this department conducted a series of Origin-Destination studies - the data, when interpreted logically, indicate a possible diversion of 34 local cars to the cut-off if built. (See tabulation which follows this discussion). Now a word as to the methods of allocating possible diversions. As of the day the study was conducted in 1936 we find a total of 62 passenger cars counted during the time period of 2 P.M. to 10 P.M.; of these, 21 drivers returned Origin-Destination cards, approximately one-third. Taking one trip as an example, that from Havre to Dawson County, it is reasonable to assume that there would be two other trips which did not report but were similar insofar as having origin west of Glasgow and destination east or southeast of Circle. By so stating the proposition, we do not thus presume to say that in the future or at the present, there are a certain stated number of trips from Havre to Dawson County. It is generally accepted that traffic will avail itself of a cut-off whenever possible; however, it is to be remembered that this trip might have been on business, the traveler might have had to make a trade "call" in Wolf Point, during half his trips. The effective diversion is therefore 1 out of 2 trips to arrive at what we deem to be a complete rationalization of the Origin-Destination Study at Circle.

Having determined the number of possible diversions from the cards returned by the travelers, the data were expanded in the ratio obtaining between the total actual count of the day of the Origin-Destination study and the 24 hours annual average traffic figure at hand in our records.

At the Origin-Destination study point near Wolf Point in 1936-1937 there was a possible local diversion of approximately 42 local cars as opposed to 34 at Circle. This disparity is believed to be the "pick up" of those McCone County residents who live north of Circle and Weldon and have occasion to travel to Wolf Point on business or other social necessity. Given an opportunity to travel to Glasgow via the proposed improvement, it is reasonable to say that there would be an effective diversion of 8 cars per day over the total length of the proposed route to arrive at a total local passenger car diversion of 42 units per day per mile.

ORIGIN DESTINATION STUDY, 1936-1937
NORTH, MONTANA 13 TO WOLF POINT AT CIRCLE

ORIGIN	NO.	POSSIBLE DIVERSION	DESTINATIONS TOWNS & CLASS NO.										COUNTIES					REMARKS
			CIRCLE	OTHERS	WOLF POINT	GLASGOW	OTHERS	GLENDIVE	OTHERS	HAVRE	OTHERS	DAWSON	McCONE	VALLEY	OTHERS	UNKNOWN		
Circle	5			1									4				Estimate 3 out of 4 trips via cut-off	
Baker	1	0.75				1											Estimate 3 out of 4 trips via cut-off	
Glasgow	1	0.75	1															
Wolf Point	1		1															
Glendive	2	0.75	1		1												Estimate 3 out of 4 trips via cut-off as indicated for Glendive-Glasgow traffic.	
Havre	1	0.50									1						Estimate half of trips via cut-off	
Helena	1	0.50					1										Estimate half of trips via cut-off	
Garfield Co.	1			1														
McCone Co.	5	0.75	3							1							Estimate 3 out of 4 trips via cut-off for McCone County - Havre traffic.	
Valley Co.	2	1.50					1				1						Estimate 3 out of 4 trips via cut-off for Valley Co. - Glendive, Dawson Co. traffic.	
Wibaux Co.	1				1													
Total Sample (Local)	21	5.50	6	1	2	2		2		1	3	4						
Total Sample (Foreign)	1	0.10											1				Estimate foreign traffic diversion 1 out of 10 trips to some destination along cut-off.	
Expand to ADT (Local)	62	16.20	17	3	6	6		6		3	9	12						
Expand to ADT (Foreign)	1	0.10											1					
Sub-Total All Traffic 2-PM to 10-PM	63	16.30	17	3	6	6		6		3	9	13						

2 PM to 10 PM
S A T O C T 17
1 9 3 6

ORIGIN DESTINATION STUDY, 1936-1937
NORTH, MONTANA 13 to WOLF POINT AT CIRCLE (Cont.)

ORIGIN	NO.	POSSIBLE DIVERSION	DESTINATIONS TOWNS & CLASS NO.							COUNTIES					REMARKS
			No 1	No 2	No 3	No 4	CIRCLE	WOLF POINT	GLASGOW	OTHERS	GLENDIVE	OTHERS	HAVRE	OTHERS	
Circle	1	0.50						1							Given an improved road via cut-off, estimate that one-half of Circle traffic will switch to Glasgow as a trading center
Fairview	1		1												
Dawson Co.	2	1.50										2			Estimate 3 out of 4 trips via cut-off for Dawson County - Valley County traffic.
McCone Co.	2		1									1			
Valley Co.	1	0.75	1												Estimate that Valley County traffic has origin at a point east of Glasgow to use PTW one-fourth of time.
Total Sample (Local)	7	2.75	3	1								1	2		
Expand to ADT (Local)	41	16.10	17	6								6	12		
Expand to ADT (Foreign)	2													2	
Sub-Total All Traffic 6AM-2PM	43	16.10	17	6								6	12	2	
Sub-Total All Traffic 6AM-10PM	106	32.40	34	12	6							9	19	12	Add ADT 2PM-10PM and ADT 6 AM-2PM
Sub-Total All Traffic 10PM-6AM	5	1.60	1	1								1	1		
ADT 1936-1937 (Pass. Cars)	111	34.00	35	13	7							3	9	20	
Exp to ADT '41 Loc.	169	53.00	55	20	11							5	14	30	
Exp to ADT '41 Fg'n	9	0.30											3		
ADT '41 Pass Cars	178	53.30	55	20	11							5	14	33	

6 AM to 2 PM SAT APR 17 1937

In the Traffic Tabulation of the route we have set up "Fort Peck Dam" traffic, this in consideration of the possible expansion or continued operation of Fort Peck as an Administrative Headquarters of the U. S. Engineer Department and in recognition of recreational facilities to be afforded in the Fort Peck area. Plans are now in the making to create a recreational area in this region with camp facilities provided by the Federal Government. This traffic increment, 25 passenger cars is deemed to be in effect only over the Circle - Fort Peck segment of the route and to be "local" in characteristic.

From Fort Peck Dam to Glasgow the route is improved to presently high standards - this traffic is predominantly local and is generated in the interest of trade and social necessity. The 1941 records show an average of 664 vehicles per day over this interval, it has remained at a consistent high level since construction of Fort Peck Dam.

For purposes of the analysis we have proceeded with the idea that out-of-state passenger car traffic is seeking recreation. Accordingly, we consider Fort Peck Dam to be a place of major interest to the tourist and when recreational facilities are provided, it is to be expected that there will be an influx of tourist traffic to the region. Furthermore, we believe that foreign traffic on U. S. 2 bound for North Dakota, Minnesota, and points east and south would see the dam via the cut-off, continue on to Glendive and thence through the North Dakota Badlands in seeking recreation. By the same token we believe that out-of-state cars would divert at Glendive to use the cut-off if given a promise of recreational facilities and scenic attraction at Fort Peck. In consideration of the tourist possibilities associated with the improvement of the route from Circle to Fort Peck Dam, the possible "foreign" diversions as of 1936 - 1937 have been doubled as of the time the

route is completed. The possible "foreign" diversions were ascertained at Origin-Destination study points at Malta and Glendive.

Given a time when the Fort Peck Dam area affords camping and recreational facilities it is believed that residents of eastern Montana will make good use of the proposed improvement. We have touched on this possibility in the discussion of the "Fort Peck Dam" traffic - such an influx of pleasure seekers would not be effective, car for car, throughout the length of the Circle-Fort Peck Dam interval. These pleasure seekers would tend to make partial use of the cut-off in that they would drive to entry roads along the course of the proposed routing then divert to the recreational area of their own choosing. The overall effect of such local travel would be anticipated in assigning a 50% increase to existing traffic on completion of a through route, this being the common practice in the preparation of economic analyses. (See Standard Traffic Estimation Procedure, page iii). Commercial or industrial traffic, trucks, trailers, etc., have been diverted to follow passenger cars in the same ratio, trucks, to passenger cars, as such traffic existed at the Origin-Destination study points.

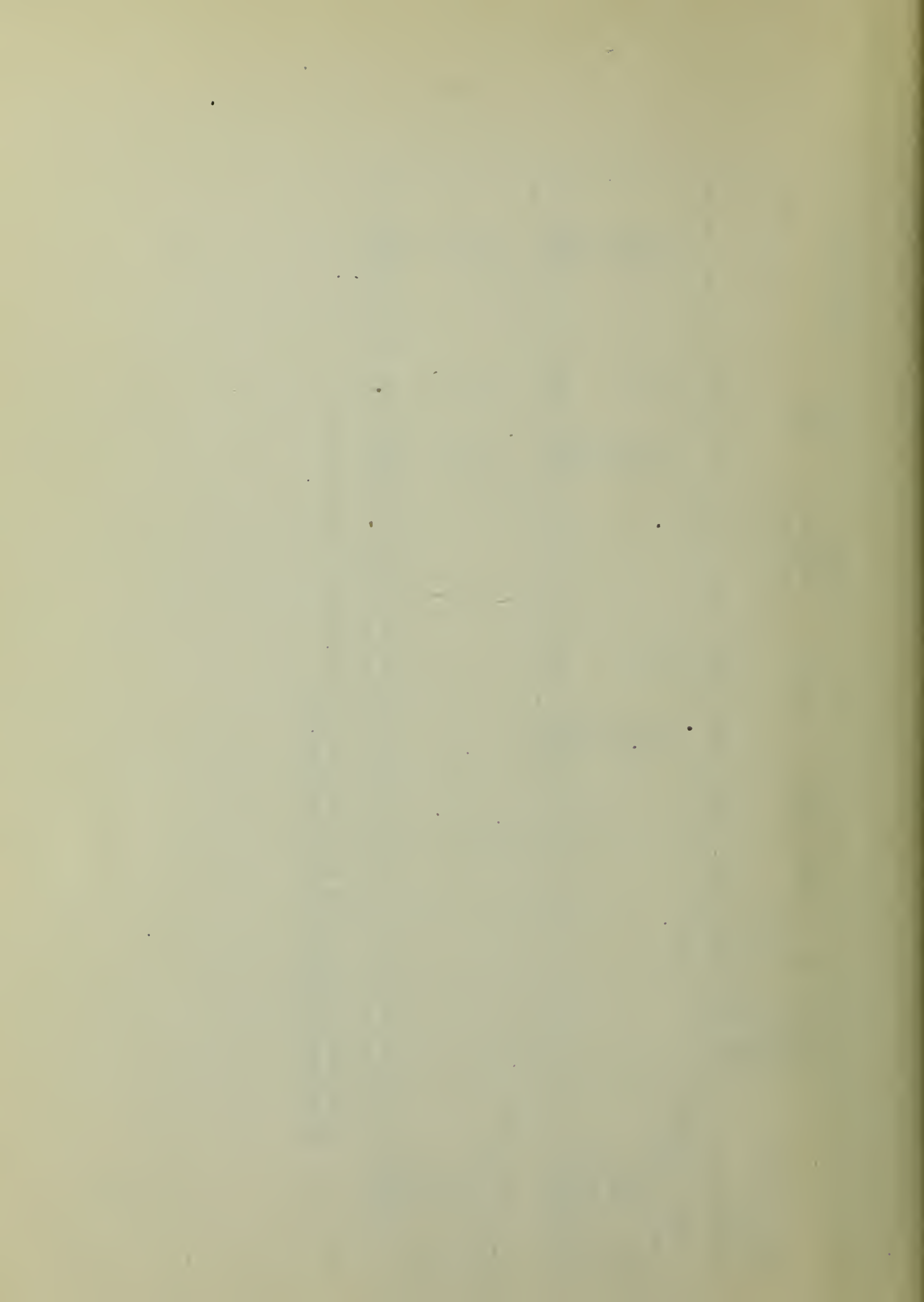
Traffic Data are summarized as follows:

Type & Class of Vehicles	1936 - 1937		1941		Completion: 1960		All Traffic
	Loc.	Fgn.	Loc.	Fgn.	Loc.	Fgn.	
Existing							
Passenger Cars							
Trucks, Light			14	1	21	1	29
Trucks, Med.			4.4		6.6		8.7
Trucks, Heavy*			.3		.5		.7
Busses, Other			.2		.3		.4
Sub Total			.1		.1		.2
Local Diversion			19	1	28.5	1	39
Passenger Cars							
Trucks, Light			42				55
Trucks, Med.			12				15.7
Trucks, Heavy*			.2				.3
Busses, Other			.4				.5
Sub Total			.4				.5
Foreign Diversion			55				72
Passenger Cars							
Trucks, Light			23		46		60
Trucks, Med.			.9		1.8		2.4
Trucks, Heavy*			.2		0.3		.4
Busses, Other			.4		.9		1.2
Sub Total			24.5		49		64
Fort Peck Dam Traffic							
Passenger Cars							
Trucks, Light			25				32
Trucks, Med.			9.7				12.5
Trucks, Heavy*			.1				.1
Busses, Other			.7				.9
Sub Total			.5				.5
Sub Total			36				46

(Continued)

[illegible]

*Includes 13.6% Heavy Trucks, 57.6% Tractor Truck - Semi-trailer Combinations and 28.8% Truck and Full-trailer combinations.



The economic analysis of the route will treat principally with benefits accruing to traffic as a result of the improvement of the Circle-Fort Peck section of the routing. The average traffic as estimated for this section in 1960 will be 221 vehicles per day.

III. SUMMARY OF FINDINGS

Detailed economic analysis as developed in Section IV of this report would recommend designation of the Circle-Glasgow road as a Federal-aid Secondary routing. Application of the Oregon solvency quotient method of analysis discloses that the road would be wholly solvent, if improved to accepted standards of construction commensurate with the traffic load. The results of the study are tabulated herebelow:

SOLVENCY RESULTS

Q_s - Solvency Quotient	Annual Income	Annual ÷ Costs	=	0.69
Q_{Bn} - Non-Fuel Benefit Quotient	Non-fuel Benefits	Annual ÷ Costs	=	0.83
Q_{Bf} - Fuel Benefit Quotient	Fuel Benefits	Annual ÷ Costs	=	0.30
Gross Solvency ($Q_s / Q_{Bn} / Q_{Bf}$)			=	1.82
Q_c - Composite Solvency $0.707 (Q_s / Q_{Bn} / Q_{Bf} (1 - K_2 K_3))$			=	1.24

IV. ECONOMIC ANALYSIS

By setting up a mathematical relationship between estimated costs on the one hand and possible future revenues and benefits on the other, we are enabled to ascertain the desirability or economic feasibility of any routing proposed for improvement. Since the discussion set forth immediately herebefore treats with traffic and since road revenue in this case grows or accumulates as a direct function of traffic we will present herewith a tabulation of possible future revenues on the proposed routing.

A. Revenues

Based on unit net revenue rates per ton mile ascertained in the course of the Montana Highway Planning Survey. Note that these basic

figures derive from the traffic summary presented herebefore, annual ton miles are obtained by multiplying average daily traffic by the length of the project by the number of days in the year, by the average gross weight of each class of traffic. Average gross weights for each class of traffic are as follows:

Passenger cars	=	1.50 tons
Trucks, light	=	3.27 tons
Trucks, medium	=	6.88 tons
Trucks, heavy	=	11.15 tons
Semi-trailer units	=	14.89 tons
Full trailer units	=	22.76 tons
Busses	=	9.00 tons

Trucks, heavy as listed in the Traffic Summary, were broken down in the percentage common to that traffic in the area: 13.6% heavy trucks; 57.6% tractor-truck, semi-trailer combinations; and 28.8% truck and full-trailer combinations. Traffic Income in whole is shown on the following page:

HIGHWAY PROJECT ANALYSIS

Location of project Montana Description of project Circle-Glasgow County McCone & Valley Traffic Income
 Highway FAS # 252 Highway System F.A. Secondary Length 85.0 miles Date of Analysis December, 1945

Traffic Type	Average Annual Traffic 1960		Average Annual		Unit Net		Total An-
	Vehicles:	Tons	Vehicle :	Ton	Road Use During Life	Revenues	
	Existing & Diverted :		Fort Peck Dam :	Fort Peck :	Miles :	Per Ton Mi.	Revenue :
Passenger Cars - Mont.	41,610	62,414	202,940	304,410	6,802,140	10,203,134	0.002188
Passenger Cars - Foreign	22,630	33,945	30,295	45,442	2,455,720	3,683,571	0.001779
Total Passenger Cars	64,240	96,359	233,235	349,852	9,257,860	13,886,705	0.002877
Trucks, light	14,345	46,909	70,810	231,549	2,354,603	7,699,621	0.003248
Trucks, medium	547	3,763	730	5,022	54,397	349,447	0.002382
Trucks, heavy	150	1,673	794	8,853	25,872	288,509	0.001619
Trucks, semi-trailer	630	9,380	3,364	50,090	109,188	1,625,750	0.001543
Trucks, full-trailer	316	7,192	1,682	38,282	54,670	1,244,272	0.001396
Busses, school							
Busses, other	437	3,933	4,380	39,420	111,395	1,002,555	0.001873
Total Trucks & Busses	16,425	72,850	81,760	373,216	2,710,125	12,210,154	0.0032431
Total all vehicles	80,665	169,209	314,995	723,068	11,967,985	26,096,859	0.0061308

Average weight of trucks 4.505 tons; All vehicles 2.181 tons. Total Annual Income... \$61,300

Percentage truck traffic 22.64%

Amortization period 20 years.

B. Annual Cost Calculations

1. Construction

a. Glasgow - Fort Peck Dam, 18 miles

By reference to "Road Life" records we find that expenditures for construction of this section during the years 1934, 1935, 1936 and 1941 total \$571,119 - \$183,560 for bridges and the balance for grading, surfacing (high type) and installation of minor drainage structures. Resolving these figures to a capital cost level the bridge cost to be amortized in 40 years at $2\frac{1}{2}\%$ interest and the other construction costs to be amortized in 20 years at $2\frac{1}{2}\%$ interest, we find that \$293,015 of the debt, so to speak, has been amortized or retired leaving \$496,065 still in the road (\$411,750 through 1963 and \$84,315 through 1975). As of 1944 the annual capital cost of this section is computed to be \$32,148, hence for 20 years subsequent thereto, the total expenditure would be \$642,960 and represents the amount necessary to keep the road section up to current high standards and to lay up a reserve for future reconstruction. But we have during the period 1944-1963, \$411,750 in the road which has come over from a previous program so we subtract this amount from the total expenditure through 1963 to leave a residual fund of \$231,210 to be amortized in the amount of \$11,560 per year. This discussion is premised in the proposition that money values are indicative of service life.

b. Circle - Fort Peck Dam, 67 miles

Estimated traffic volume as of 1960 would warrant construction to Standard No. 6 as set forth in "Basic Design Categories," (see pages i and ii). Construction experience in this area to comparable standards is listed on the following page:

SECONDARY ROAD CONSTRUCTION

TERRY - BROCKWAY

TOTAL COSTS BY ITEM, DOLLARS

Pro- ject No.	: Length	: ing	: Major Struc- tures	: Minor Struc- tures	: Drainage Struc- tures	: Oil Surf- acing	: Gravel: Surf- acing & Base Const-	: Engr.	: Right of Way
302A	: 6.9	:15,397	: 27,206	: 4,711	:	:14,269	: 3,488	: 1,258	
302B	: 4.5	:11,473	: 8,645	: 4,187	:	: 8,500	: 2,549	: 1,369	
302C	: 5.7	:19,710	: 4,894	: 9,244	:	:	: 3,049	:	
302D	: 4.9	:10,533	: 9,004	: 5,663	:	: 9,538	: 3,158	:	
Totals	: 22.0	:57,113	:49,749	:23,805	:	:32,307	:12,244	: 2,627	
Averages x/22.0	:	:\$2,596	:\$2,261	:\$1,082	:	:	:\$557	:	
Averages x/16.3	:	:	:	:	:	:\$1,982	:\$564	:	
Averages x/11.4	:	:	:	:	:	:	:\$529	:\$230	

PRIMARY ROAD CONSTRUCTION

CIRCLE - WOLF POINT

Pro- ject No.	: Length	: ing	: Major Struc- tures	: Minor Struc- tures	: Drainage Struc- tures	: Oil Surf- acing	: Gravel: Surf- acing & Base Const-	: Engr.	: Right of Way
253B	: 7.6	:32,513	: 12,371	: 7,103	: 3,127	:21,188	: 5,100	: 3,241*	
253C	: 13.1	:53,913	: 20,385	:14,436	:11,187	:54,671	:11,108	: 4,828	
253F	: 7.2	:26,003	: 13,731	:12,357	:13,635	:44,800	: 6,537	: 3,325	
Totals	: 27.9	:112,429	:46,487	:33,896	:27,949	:120,659	:22,745	:11,394	
Averages x/27.9	:	:\$4,030	:\$1,666	:\$1,215	:	:\$4,325	:\$815	:\$408	
Averages x/20.3	:	:	:	:	:\$1,223	:	:\$869	:	
Averages x/7.6	:	:	:	:	:\$ 411	:	:\$671	:	*

* Penetration Oiling

Drawing on these "experience" data and recognizing a probable increase in unit prices during the post-war period we have estimated costs per mile as follows:

Grading..... \$3,300

Assuming that prices will strike on average between the Terry - Brockway (secondary) costs and the Circle - Wolf Point (primary) costs.

Major Structures..... \$1,700

Assuming conditions analogous to the Circle-Wolf Point construction but to a lesser standard

to compensate for any probable unit price rise.

Minor Drainage Structures..... \$1,300

Assuming conditions similar to the Terry -
Brockway construction plus 20%.

Oil Surfacing, 2"..... \$1,200

Assuming conditions similar to the Circle-
Wolf Point construction but lesser quan-
tities per mile to compensate for a probable
increase in unit prices.

Gravel Surfacing & Base Construction..... \$4,200

Assuming that there will be somewhat less gravel
surfacing quantities than the Circle - Wolf Point
construction and that the unit prices will be
relatively higher.

Engineering..... \$ 900

Assuming that engineers will be raised in pay
along with grease monkeys, oilers, and blonde
stenographers.

Right-of-way..... \$ 250

Assuming costs similar to those for the Terry -
Brockway construction.

Estimated cost per mile, Sub-Total..... \$12,850

Add 10% for administration, overhead and contingencies 1,285

Total Estimated cost per mile..... \$14,135

The total estimated cost for the improvement of the Circle - Fort Peck
section would be $\$14,135 \times 67 = \$947,045$. This amount when amortized at
 $2\frac{1}{2}\%$ in 20 years resolves into an annual cost of \$60,705. These data are
set forth in lesser detail on the "Annual Cost Calculations", (see
following page).

ANNUAL COST CALCULATIONS

Location of Project Montana County McCone & Valley
 Description of project Circle - Glasgow
 Highway number FAS No. 252 Highway system F.A. Secondary
 Length 85.0 miles Date of analysis December, 1945

CAPITAL COSTS

Item	Net Cost	Gross Cost <u>2/</u>	Amort. Period	Annual Capital Cost
Rights of way, easements, etc.	\$ 16,750	\$		\$ 11,560 <u>1/</u>
Clearing, grading, etc.	221,100			
Pavements and surfacing:	361,800			
Structures:				
Type <u>Major</u>	113,900			
Type <u>Minor</u>	87,100			
Signs, lights, signals etc....				
Other Construction items:.....	146,395			
Cost new Construction.....	947,045		20yrs. @ <u>2 1/2%</u>	60,705
1. Total annual capital cost.....				\$ 72,265

MAINTENANCE COSTS

2. Total annual maintenance cost <u>85 x 200</u>	\$ 17,000
TOTAL ANNUAL COSTS (1 <u>+</u> 2.)	\$ 89,265

- 1/ Computed Annual Capital Cost for the Fort Peck - Glasgow Section.
 2/ Included in "Other Construction Items"
 3/ Included in overall estimate for maintenance costs.

2. Maintenance Costs

From data at hand in the Maintenance Department we find maintenance costs on the Glasgow - Fort Peck Dam section to have been \$250 per mile per year over a 10-year period. It is reasonable to think that the average maintenance cost per mile per year over the total length of the route being studied should not exceed \$200.

C. Time Element Savings

By reason of improvement of the Fort Peck - Circle section of the route that traffic which now uses the route, the "Dam" traffic and the diverted traffic would be enabled to take the cut-off at greatly accelerated

speeds to effect a material time saving. Applying unit time values as prescribed in Technical Bulletin No. 7, "The Economics of Highway Planning," Oregon Highway Department, we arrive at an annual value for time savings. The tabulation follows this discussion. Note that there are no time savings computed for that traffic which now uses the Fort Peck - Glasgow section -- this section is presumed, for purposes of analysis, to be improved, and no time saving would be effected should the section be reconstructed in the future. Speed rates, "PTW" and "New" derive from rates established in the Oregon Technical Bulletin.

Time Element Savings

HIGHWAY PROJECT ANALYSIS

Location of project Montana County McCone & Valley
 Description of project Circle - Glasgow
 Highway number FAS No. 252 Highway System F. A. Secondary
 Length 67 Date of analysis December, 1945

Annual Traffic Volume	Existing Traffic		Fort Peck Dam	
	New	PTW ^{2/}	New	PTW
Private Passenger cars (per year)	10,585		11,680	
Trucks, light (per year).....	3,176		4,563	
Trucks, medium (per year).....	255		36	
Trucks, heavy (per year).....	219		511	
Busses (per year) ^{1/}				
Totals.....	14,235		16,790	
Private Passenger Cars				
Average speed (miles per hour)..<	43	30	43	43
Distance (Miles).....	67	71	67	100
Time (hours per trip).....	1.558	2.367	1.558	2.326
Time savings per vehicle.....	0.809		0.768	
Value of savings (\$/vehicle-hour)	\$0.60		\$0.60	
Annual traffic volume.....	10,585		11,680	
Total.....	5,138		\$5,382	
Trucks, Light				
Average speed (miles per hour)..<	39	27	39	39
Distance (miles).....	67	71	67	100
Time (hours per trip).....	1.718	2.630	1.718	2.564
Time savings per vehicle.....	0.912		0.846	
Value of savings (\$/vehicle-hour)	\$0.86		\$0.86	
Annual traffic volume.....	3,176		4,563	
Total.....	\$ 2,491		\$3,320	

^{1/} Busses, tractor-truck, Semi-trailer, and truck and full trailer combinations included with trucks, Heavy

^{2/} PTW = present traveled way.

		Time Element Savings (Cont)			
		Existing Traffic		Fort Peck Dam	
		New	PTW	New	PTW
<u>Trucks, Medium</u>					
Average speed (miles per hour).		35	24	35	35
Distance (miles).....		67	71	67	100
Time (hours per trip).....		1.914	2.958	1.914	2.857
Time savings per vehicle.....		1.044		0.943	
Value of savings(\$/vehicle-hour)		\$1.17		\$1.17	
Annual traffic volume.....		225		36	
Total.....		\$311		\$40	
<u>Trucks, Heavy</u>					
Average speed (miles per hour).		32	22	32	32
Distance (miles).....		67	71	67	100
Time (hours per trip).....		2.094	3.227	2.094	3.125
Time savings per vehicle.....		1.133		1.031	
Value of savings(\$/vehicle-hour)		\$1.47		\$1.47	
Annual traffic volume.....		219		511	
Total.....		\$365		\$774	
Total savings each class'n		\$8305		\$9516	
SUB-TOTAL ANNUAL TIME ELEMENT SAVINGS				\$17,817	

HIGHWAY PROJECT ANALYSIS

Time Element Savings

Location of project Montana County McCone & Valley
Description of project Circle - Glasgow
Highway number FAS No. 252 Highway System F.A. Secondary
Length 85.0 miles Date of analysis December, 1945

		Diverted Traffic	
		New	PTW
<u>Annual Traffic Volume</u>			
Private Passenger cars (per year)..		41,975	
Trucks, light (per year).....		6,606	
Trucks, Medium (per year).....		256	
Trucks, heavy (per year).....		803	
Totals.....		49,640	
<u>Private Passenger Cars</u>			
Average speed (miles per hour).....		43	43
Distance (miles).....		85	102
Time (hours per trip).....		1.977	2.372
Time savings per vehicle.....		0.395	
Value of savings (\$/vehicle-hour)..		\$0.60	
Annual traffic volume.....		41,975	
Total.....		\$9,948	
<u>Trucks, Light</u>			
Average speed (miles per hour).....		39	39
Distance (miles).....		85	102
Time (hours per trip).....		2.179	2.615
Time savings per vehicle.....		0.436	
Value of savings (\$/vehicle-hour)..		\$0.86	
Annual traffic volume.....		6,606	
Total.....		\$2,477	

Time Element Savings (Cont.)

Diverted Traffic

New

PTW

Trucks, Medium

Average speed (miles per hour).....
Distance (miles).....
Time (hours per trip).....
Time savings per vehicle.....
Value of savings (\$/vehicle-hour)....
Annual traffic volume.....
Total.....

35
85
2.429
0.485
\$1.17
256
\$145

35
102
2.914

Trucks, Heavy

Average speed (miles per hour).....
Distance (miles).....
Time (hours per trip).....
Time savings per vehicle.....
Value of savings (\$/vehicle-hour)....
Annual traffic volume.....
Total.....

32
85
2.656
0.531
\$1.47
803
\$627

32
102
3.187

Total savings each class'n

\$13.197

\$17,821 from page 18

TOTAL ANNUAL TIME ELEMENT SAVINGS.....

\$31,018

D. Mileage Element Savings

These savings accrue to traffic by virtue of distance savings and the provision of better driving conditions. In short, it is presumed that "wear and tear" on vehicles will be lessened by reason of the improvement. Utilizing such applicable data as are available in the Technical Bulletin, we find Mileage Element Savings to be as follows:

HIGHWAY PROJECT ANALYSIS

Mileage Element Savings

Location of project Montana County McCone - Valley
Description of project Circle - Glasgow
Highway number FAS No. 252 Highway System F. A. Secondary
Length 67 miles Date of Analysis December, 1945

	Existing Traffic		Diverted Traffic	
	New	PTW	New	PTW
Distance 1/ Length (miles).....	67	71	85	102
Distance saving (miles)....	4		17	
Average annual traffic (tons)	31,104		98,300	
Annual traffic saving (ton-mi)	124,416		1,671,100	
Cost (\$/ton-mile).....	0.0195		0.0199	
Total.....	\$ 2,426		\$ 33,255	

Mileage Element Savings (Cont.)				
	Existing Traffic		Diverted Traffic	
	New	PTW	New	PTW
Surface <u>2/</u>				
Roadway surface type.....	Oil - 0.19	Unimp. 0.00		
Saving coefficient.....	0.19			
Aver. annual traffic (ton-mi.)	2,083,968			
Saving (\$/ton-mile).....	0.003705			
Total.....	\$ 7,721			
Rise and Fall <u>3/</u>				
Rise and fall (feet).....				
Saving (feet).....				
Saving (foot-tons).....				
Saving (\$/foot-ton).....				
Total.....				
Gradient <u>4/</u>				
Gradients in per cent.....				
Red'n in gradient.....				
Average An. Traffic (Ton-mi.)				
Saving (\$/ton-mile).....				
Total.....				
Alignment <u>5/</u>				
Curvature rating.....	10	2		
Points improvement.....	8			
Saving (point-ton-miles).....	16,671,744			
Saving (\$/point-ton-mile).....	\$0.0001			
Total.....	\$1,667			
Traffic Stops <u>6/</u>				
Number per year.....				
Eliminated per year.....				
Aver. vehicular weight (tons)				
Saving (\$ per ton-per stop)...				
Total Each Class'n.....	\$ 11,814		\$33,255	
TOTAL ANNUAL MILEAGE ELEMENT SAVINGS		\$ 45,069		

HIGHWAY PROJECT ANALYSIS

Location of project	Montana	Mileage Element Savings
Description of project	Circle - Glasgow	County McCone - Valley
Highway number	FAS No. 252	Highway system F. A. Secondary

Fort Peck Dam Traffic		
Distance	New	PTW
Length (miles).....	67	100
Distance saving (miles).....	33	
Average annual traffic (tons)...	39,805	
Annual traffic saving (ton-mile)	1,313,565	
Cost (\$/ton-mile).....	\$0.0193	
Total.....	\$25,352	

Mileage Element Savings (Cont)

Fort Peck Dam Traffic

Total Each Class'n.....	<u>New</u> \$25,352	<u>PTW</u> \$45,069 - from page 20
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TOTAL ANNUAL MILEAGE ELEMENT SAVINGS

\$ 70,421

Now a word as to the allocation of mileage element savings to each of the several classifications of traffic involved in this analysis.

1. EXISTING TRAFFIC. This traffic will be benefited by reason of wearing surface improvement and alignment improvement and a decrease in travel distance. Wear and tear on vehicles will be decreased; there will be no low gear operation through hub deep gumbo. As shown heretofore the distance from Circle to Fort Peck will be shortened by four miles. Such an eventuality will of course benefit "Existing Traffic" by reason of distance saved - it would also decrease the annual capital costs of the route as a whole and add to the benefits foreseen for the diverted traffic and the Fort Peck Dam traffic.

2. DIVERTED TRAFFIC AND FORT PECK DAM TRAFFIC. Diverted traffic will be benefited by reason of distance savings - and distance savings only. The roads that this traffic will be diverted from will be equivalent to the Circle - Glasgow road insofar as wearing surface, alignment, rise and fall, gradient, etc., are concerned.

3. FORT PECK GLASGOW TRAFFIC. No benefits accrue to this traffic by reason of the improvement of the Fort Peck - Circle road. It is, of course, probable that this traffic will avail itself of new trade areas and recreational outlets on completion of the Fort Peck - Circle section of the route. We believe, however, that these benefit elements are covered in the 50% traffic increase allowed for completion of the road as a through route.

1/ These values are obtained by using certain procedures and formulae set forth in the Oregon Technical Bulletin. Given the components of traffic one may compute ton mile costs as follows:

Existing Traffic:

$$\frac{\text{Trucks, Vehicles}}{\text{All Traffic, Vehicles}} = \frac{3650}{14235} = 25.64\% \text{ trucks}$$

$$\frac{\text{Trucks, tons} \times 2000}{\text{Trucks, Vehicles}} = \frac{15227 \times 2000}{3650} = 8344 = \text{Average weight of trucks in pounds.}$$

By reference to figure 113 of the Technical Bulletin we find the mileage element cost for an average gross weight of 8344 pounds to be \$0.016 per ton mile. The mileage element cost for a passenger car is given as \$0.0207 per ton mile. Combining these data in the proportion ascertained heretofore we have:

Trucks,	$0.2564 \times 0.016 = 0.0041$
Pass. Vehicles	$0.7436 \times 0.0207 = 0.0154$
All Traffic	$1.0000 \times 0.0195 = 0.0195$

Diverted Traffic:

$$\frac{\text{Trucks, Vehicles}}{\text{All Traffic, Vehicles}} = \frac{7665}{49640} = 15.44\% \text{ trucks}$$

$$\frac{\text{Trucks, tons} \times 2000}{\text{Trucks, Vehicles}} = \frac{35,338 \times 2000}{7665} = 9,221 = \text{Average weight of trucks in pounds}$$

Mileage element cost for an average gross weight of 9221 pounds is found to be \$0.0155.

Trucks,	$0.1544 \times 0.0155 = 0.0024$
Pass. Vehicles,	$0.8456 \times 0.0207 = 0.0175$
All Traffic,	$1.0000 \times 0.0199 = 0.0199$

Fort Peck Dam Traffic:

$$\frac{\text{Trucks, Vehicles}}{\text{All traffic, vehicles}} = \frac{5110}{16790} = 30.43\% \text{ trucks}$$

$$\frac{\text{Trucks, tons x 2000}}{\text{Trucks, Vehicles}} = \frac{22,285 \times 2,000}{5110} = 8,722 = \text{Average weight of trucks in pounds.}$$

Mileage element cost for an average gross weight of 8722 pounds is found to be \$0.0160 by reference to Figure 113 of the Technical Bulletin.

$$\text{Trucks, } 0.3043 \times 0.0160 = 0.0049$$

$$\text{Passenger cars, } 0.6957 \times 0.0207 = 0.0144$$

$$\text{All Traffic } 1.0000 \times 0.0193 = 0.0193$$

2/ The values are based on coefficient savings as set forth in the Technical Bulletin. Given an improvement to "oil", coefficient 0.00 from "unimproved", coefficient 0.19, we find a relative improvement of 0.19. Applying this coefficient to the ton mile cost, thus, 0.0195×0.19 we have a resultant ton mile savings of \$0.003705.

3/ No significant change in Rise and Fall.

4/ No significant change in Gradient.

5/ Alignment - it is presumed that the alignment will be bettered by eight points as per the procedure outlined in the Technical Bulletin. The Bulletin ascribes a value of \$0.0001 per point ton mile for improvements in alignment.

6/ No significant elimination of traffic stops.

E. Traffic Benefits

Being a recapitulation of Time Element Savings and Mileage Element Savings allocated to fuel and non-fuel function benefits. Factors in the development of this tabulation derive from the Technical Bulletin.

HIGHWAY PROJECT ANALYSIS

Traffic Benefits

Location of project	Montana	County	McCone - Valley
Description of project	Circle - Glasgow		
Highway number	FAS No. 252	Highway system	F.A. Secondary
Length	85.0 miles	Date of analysis	December, 1945

Mileage Element Factors

Item	Fuel Function	Non-fuel Function
Distance savings-----	38% 23,193	62% 37,840
Roadway surface savings-----	41% 3,166	59% 4,555
Alignment savings-----	50% 834	50% 833
Total Mileage Savings-----	\$ 27,193	\$ 43,228

Time Element Factors

Other Benefit Items

Type of Traffic	Annual Value of Time Savings	Item	Value
Passenger cars-----	\$ 20,468		\$
Trucks, light-----	8,288		
Trucks, medium-----	496		
Trucks, heavy-----	1,766		
Total Time Savings \$	31,018		

Recapitulation of Annual Benefits

Total Fuel Function Benefits-----	\$ 27,193
Non-fuel function (Mileage element factors \$ 43,228 benefits (Time element factors \$ 31,018)	
Total Non-fuel Function Benefits-----	\$ 74,246
TOTAL ANNUAL BENEFITS-----	\$ 101,439

F. Derivation of Benefit Quotients

We now have all facts essential to the mathematical analysis of the proposed route - we have the annual capital cost, the estimated annual revenue, and the estimated annual monetary value of the benefits. These data with notes, are set out hereinafter.

HIGHWAY PROJECT ANALYSIS

Location of project	Montana	County	McCone - Valley
Description of project	Circle - Glasgow		
Highway number	FAS No. 252	Highway system	F. A. Secondary
Length	85.0 miles	Date of analysis	December, 1945

$$\begin{aligned}
 I_{ar} &= \$ 61,300 \quad \frac{1}{K_1} = 1.0 \\
 C_a &= \$ 89,265 \quad \frac{2}{K_2} = 22.271 / 27,193 = 0.82 \\
 B_n &= \$ 73,680 \quad \frac{3}{K_3} = 0.05 / 0.20 = 0.25 \\
 B_f &= \$ 26,846 \quad K_2 K_3 = 0.82 \times 0.25 = 0.205 \\
 \frac{4}{K_1 C_a} &= \$ 89,265 \quad 1 - K_2 K_3 = 1.00 - 0.205 = 0.795 \\
 \frac{5}{Q_s} &= I_{ar} / K_1 C_a = 61,300 / 89,265 = 0.69 \\
 \frac{6}{Q_{Bn}} &= B_n / K_1 C_a = 73,680 / 89,265 = 0.83 \\
 \frac{7}{Q_{Bf}} &= B_f / K_1 C_a = 26,846 / 89,265 = 0.30 \\
 \frac{8}{Q'_s} &= Q_s - K_2 K_3 Q_{Bf} = 0.69 - 0.205 \times 0.30 = 0.69 - 0.06 = 0.63 \\
 \frac{9}{Q_c} &= 0.707 (Q_s / Q_{Bn} / Q_{Bf} (1 - K_2 K_3)) = 0.707 (0.69 / 0.83 / 0.30 \times 0.795) \\
 &= 0.707 (0.69 / 0.83 / 0.24) \\
 &= 0.707 \times 1.76 \\
 &= 1.24
 \end{aligned}$$

1/ The constant K_1 represents the pro rata of cost chargeable to road user funds.

2/ The constant K_2 represents the proportion of the total fuel savings which is derived from traffic drained away from existing routes. Refer to the tabulation of Mileage Element Savings and find that the distance savings, surface type savings, and alignment savings are effective in respect to all traffic except the Glasgow-Fort Peck Dam traffic. The fuel savings, as they benefit each category of traffic are set forth on the following page:

	:	:	Diverted	:
	:	:	Traffic &	:
	:	Existing	Fort Peck Dam	Total Fuel
Mileage Element	:	Traffic	Traffic	Savings
Distance Savings	:	922	12,637	13,559
Distance Savings	:		9,634	9,634
Surface Savings	:	3,166		3,166
Alignment savings	:	834		834
Totals	:	\$4,922	\$22,271	\$27,193

3/ The constant K_3 represents the ratio of fuel tax to total cost of fuel. As a matter of interest, if we take the fuel savings, accruing to the Diverted Traffic and the Fort Peck Dam Traffic, \$27,193 and multiply by this factor, we get \$6,792, the net decrease in gas tax revenues for US-2 and Mont. 22 in the area of the improvement. This to illustrate the need for the derivation of these constants in any analysis of highway economics.

4/ By applying the constant K_1 to the annual capital costs, we find the pro rata cost payable out of road user funds.

5/ Q_s represents the solvency quotient - if it were 1.00, annual revenue would balance estimated annual expenditures. In this case the solvency quotient is 0.69, estimated revenues do not balance expenditures by an appreciable sum - at first glance one would say the routing is not feasible, economically. But the highway picture involves a whole lot more than the mere comparison of income and expenditure - there are benefits which accrue to the road user which have an important bearing in the matter. The situation might be likened to a newspaper enterprise - in this sort of endeavor, subscriptions and street sales do not ordinarily pay the costs of publishing. However, the newspaper is an advertising medium and the fees for running ads will put the business on the "profit" side of the ledger. In the highway business, we have, in addition to our estimated revenues, the probable benefits to traffic which will result as a consequence of improvement. This is our "advertising", so to speak.

6/ and 7/ Q_{Bn} and Q_{Bf} represent the benefit quotients, non-fuel and fuel. By adding these quotients to the solvency quotient we would find the value of our "gross" to be 1.82, our "costs" would be 1.00, so our "profit" to the road user would be 0.82.

8/ Q'_s is the corrected solvency quotient - the Circle-Glasgow road, if built and thus entered in the "corporation" of Montana roads will act to decrease the revenues of those routes from which traffic is diverted. Q'_s represents the net solvency of the improvement in respect to other parts of the plant.

9/ Q_c represents the composite quotient. Heretofore we have determined financial solvencies, now we compare benefits with revenues to determine the feasibility or desirability of the route. Given a situation whereby the benefits would balance income - the driver would simply accumulate sufficient funds to pay his taxes and no more. In this particular instance however the benefits are in excess of revenues to render the proposed routing a working partner in the Montana Secondary Road System.

V. RECOMMENDATIONS

The subject matter of this report treats with the highway economics attaching to a proposed secondary routing from Circle to Glasgow and in view of the favorable circumstances brought to light in the analysis, it is recommended that Federal-aid Secondary Route No. 252 be extended to a junction with Federal-aid Route No. 1 in Glasgow.

In consonance with the action suggested above, it is recommended that Federal-aid Route No. 42 be withdrawn from the Primary System. This route, by virtue of its location (see map, frontspiece) is lacking in traffic potentialities. It is "out of the way" for that traffic which might originate in

southeastern Montana, bound for Fort Peck, Glasgow, and points west in northern Montana. Existing routes Federal-aid Nos. 1, 15, 17, and 25 serve such traffic which might originate in central and south-central Montana, bound for Glasgow and points east. The area immediately served by Federal-aid Route No. 42 as originally designated is sparsely populated. The local economy is based principally on grazing -- there is no present indication that the economic picture will change to create a need for a primary routing through the region. Federal-aid Secondary Route No. 252 will be coincident with Federal-aid Route No. 42, for approximately three-fourths of the distance involved and there is little question but that it will serve the people of McCone County better than Federal-aid Route No. 42 as it traverses a more populous area and will at the same time serve through traffic just as well as Federal-aid Route No. 42, and it is self-evident from the analysis that one route only is justified. Consequently, it is recommended that Federal-aid Route No. 42 be eliminated from the Federal-aid System and Federal-aid Secondary Route No. 252 be extended to Glasgow.

Prepared and submitted by:

The Montana Highway Planning Survey

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